CLAIMS

1. A method of changing gear in an automated transmission system of a motor vehicle including:-

a multi-ratio gearbox having at least two shafts including an input shaft and an output shaft;

a take-up clutch located between the input shaft and an output shaft of an engine by which torque may be transmitted between the engine and the input shaft;

a number of pairs of intermeshing gears, one gear of each pair being mounted in fixed rotational relationship with one of said shafts and the other gear of each pair being rotatably mounted with respect to another shaft;

the rotatably mounted gears of each pair of gears having means for selectively rotatably securing the gears to said other shaft;

a power shifting clutch being adapted to rotatably secure the rotatably mounted gear of a first pair of gears to said other shaft; and

means for sensing the speed of the input shaft and the speed of the output shaft of the gearbox;

in which when the vehicle is in motion, the take-up clutch will be engaged to transmit torque from the engine to the input shaft of the gearbox and the rotatably mounted gear of one pair of gears is rotatably secured to said other shaft to engage said pair of gears and transmit torque from the input shaft to the output shaft; said method comprising:-

a) engaging the power shifting clutch so that the torque transmitted through the currently engaged gear is gradually diverted through the power shifting clutch and said first pair of gears associated therewith;

b) when the torque transmitted by the power shifting clutch is equal to the engine torque, within prescribed limits, the currently engaged gear is disengaged;

c) following disengagement of the currently engaged gear, the power shifting clutch and/or the engine are controlled to increase the torque difference between the torque transmitted by the power shifting clutch and the torque produced by the engine, to a first predetermined value, so as to bring the synchronisation speed $\Delta\omega$ towards zero, where:

synchronisation speed $\Delta\omega = \omega_{mot} - i\omega_{lsk}$

where; ω_{mot} = the input shaft speed;

ω_{lsk} = the output shaft speed; and

i = the gear ratio of a target gear;

d) after a first predetermined time period the power shifting clutch and/or engine being controlled to reduce the difference between the torque transmitted by the power shifting clutch and the torque produced by the engine so that the synchronisation speed and acceleration of the input shaft level off towards zero; and

e) engaging the relatively rotatable gear of the target gear with said other shaft, when the synchronisation speed is at zero, within prescribed limits.

2. A method according to claim 1 wherein, after disengagement of the currently engaged gear;

a) the torque transmitted by the power shifting clutch is increased and/or the engine torque is reduced, for an up-shift; and

b) the torque transmitted by the power shifting clutch is decreased and/or the engine torque is increased for a down-shift.

3. A method according to claim 2 wherein the torque transmitted by the power shifting clutch and/or engine torque are changed by a step, a ramp or a non-linear command path.

4. A method according to claim 1, wherein the first predetermined torque difference is a function of the gear shift, criteria related to driver comfort and/or limitations of the transmission system.

5. A method according to claim 1, wherein the torque difference is reduced to the second predetermined value by altering the torque transmitted by the power shifting clutch and the engine torque, at the same time.

6. A method according to claim 1, wherein the second predetermined value is zero.

7. A method according to claim 6, wherein the torque difference is reduced to the second predetermined value by returning the torque transmitted by the power shifting clutch and the engine torque, to the value thereof when the currently engaged gear was disengaged.

8. A method according to claim 1, wherein the predetermined time period

$$t_o = J_{mot} \frac{\Delta\omega_o}{M_H - M_L}$$

where;

J_{mot} = input inertia of the engine;

$\Delta\omega_o$ = synchronising speed at time t_o;

$M_H - M_L$ = the first predetermined torque difference.

9. A method according to claim 1, wherein the second predetermined torque difference is a function of vehicle acceleration during the synchronisation phase of the gear change.

10. A method according to claim 9, wherein the predetermined time period

$$t_1 = J_{mot} \frac{\Delta\omega_o}{M_H - M_L + J_i a_{frg}}$$

where;

a_{fzg} = the vehicle acceleration

and $\Delta\omega$ = $\omega_{mot} - i(\omega_{fzg} + a_{fzg}[t - t_o])$.

11. A method according to claim 1, wherein the input and output shaft speeds of the gearbox are monitored and the actual synchronisation speed is determined from the input and output shaft speeds and the target gear ratio, the actual synchronisation speed being used in a closed feedback loop to ensure accurate and smooth reduction of the synchronisation speed to zero.

12. A method according to claim 11, wherein the feedback loop controls the amount of torque transmitted by the power shifting clutch, so as to adjust the first predetermined torque difference to a value appropriate for the instantaneous synchronisation speed.

13. A method according to claim 12, wherein the feedback loop is actuated when the synchronisation speed approaches zero.

14. A method according to claim 13, wherein the feedback loop is actuated after a second predetermined time period has elapsed from disengagement of the currently engaged gear.

15. A method according to claim 14, wherein the second predetermined time period coincides with the first predetermined time period.

16. A method according to claim 13, wherein the feedback loop is actuated when the synchronisation speed falls below a predetermined value.

17. A method according to claim 11, wherein the feedback loop compares the actual instantaneous synchronisation speed with a reference synchronisation speed and increases or decreases the torque transmitted by the power shifting clutch so that the first predetermined torque difference is adjusted in accordance with the difference between the actual and reference synchronisation speed.

18. A transmission system for a motor vehicle including:-

a multi-ratio gearbox having at least two shafts including an input shaft and an output shaft;

a take-up clutch located between the input shaft and an output shaft of an engine by which torque may be transmitted between the engine and the input shaft;

a number of pairs of intermeshing gears, one gear of each pair being mounted in fixed rotational relationship with one of said shafts and the other gear of each pair being rotatably mounted with respect to another shaft;

the rotatably mounted gears of each pair of gears having means for selectively rotatably securing the gears to said other shaft;

a power shifting clutch being adapted to rotatably secure the rotatably mounted gear of a first pair of gears to said other shaft; and

means for sensing the speed of the input shaft and the speed of the output shaft of the gearbox; and

means for initiating a change from one gear to another;

in which when the vehicle is in motion, the take-up clutch will be engaged to transmit torque from the engine to the input shaft of the gearbox and the rotatably mounted gear of one pair of gears is rotatably secured to

said other shaft to engage said pair of gears and transmit torque from the input shaft to the output shaft;

means being provided which, upon actuation of the means for initiating a chance from one gear to another, for engaging the power shifting clutch so that the torque transmitted through the currently engaged gear is gradually diverted through the power shifting clutch and said first pair of gears associated therewith;

means being provided for disengaging the currently engaged gear when the torque transmitted by the power shifting clutch is equal to the engine torque, within prescribed limits;

means being provided by which, following disengagement of the currently engaged gear, the power shifting clutch and/or the engine are controlled to increase the torque difference between the torque transmitted by the power shifting clutch and the torque produced by the engine, to a first predetermined value, so as to bring the synchronisation speed $\Delta\omega$ towards zero, where:

$$\text{synchronisation speed } \Delta\omega = \omega_{mot} - i\omega_{isk}$$

where; ω_{mot} = the input shaft speed;

ω_{isk} = the output shaft speed; and

i = the gear ratio of a target gear;

means being provided to reduce the difference between the torque transmitted by the power shifting clutch and the torque produced by the engine, after a first predetermined time period has elapsed since disengagement of the currently engaged, so that the synchronisation speed and acceleration of the input shaft level off towards zero; and

means being provided for engaging the relatively rotatable gear of the target gear with said other shaft, when the synchronisation speed is at zero, within prescribed limits.

19. A transmission system according to claim 18 including a closed loop feedback which controls engagement of the power shifting clutch, to

increase or decrease the torque transmitted thereby, between disengagement of the currently engaged gear and engagement of a target gear, so as to bring the synchronisation speed accurately and smoothly towards zero.

20. A transmission system according to claim 19, wherein the closed loop feedback controls the power shifting clutch in accordance with the instantaneous synchronisation speed as determined from the input shaft speed as monitored by input shaft speed sensor, the output shaft speed as monitored by the output shaft speed sensor and the known target gear ratio.

21. A transmission system according to claim 20, wherein switching means is provided for enabling the closed loop feedback as the synchronisation speed approaches zero.

22. A transmission system according to claim 19, wherein the closed loop feedback controls the power shifting clutch in accordance with a comparison of the actual instantaneous synchronisation speed; as determined from the input shaft speed as monitored by input shaft speed sensor, the output shaft speed as monitored by the output shaft speed sensor and the known target gear ratio; with a reference synchronisation speed.